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(54) **Process for production of self-crimping polyester yarn.**

(57) Polyester polymer is extruded at different speeds through parallel closely spaced orifices (20, 22) at relatively high spinning speeds. The resulting filament has high and low shrinkage regions substantially regularly spaced apart along its length. A yarn including a number of these filaments spontaneously develops crimps when relaxed.

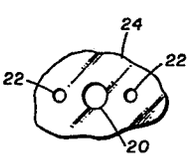

FIG.1.

FIG.2.

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PROCESS FOR PRODUCTION OF SELF-CRIMPING POLYESTER YARN

The invention relates to the art of producing a polyester filament with high and low shrinkage regions along its length, such that a yarn including a number of these filaments spontaneously develops crimp when relaxed.

Japanese patent publication number 22339/1967 discloses extruding at low spinning speeds various polymers through combined orifices, each combined orifice including a large diameter central capillary and two or more small diameter satellite capillaries, the lengths of the various capillaries being unspecified. The spun yarns are then drawn under unspecified conditions to yield drawn filaments having cross-sectional shapes which vary continuously and cyclically along the length of each filament. When attempts were made to duplicate the teachings of this reference with polyester polymer, yarn drawn at normal draw ratios and relaxed while being heated exhibited a small amount of crimp, but not to a useful degree. When the draw ratio is reduced experimentally to an unusual ratio, the crimp level in the relaxed yarn increases to a marginally useful level. However, facrics made from either of these yarns have a harsh hand.

Japanese patent publication 42,415/1979 discloses spinning two polyester streams through a spinneret with converging capillaries wherein the streams intersect in mid-air (below the spinneret) to form a combined stream. One of the streams has a higher speed than the other, and an oscillation occurs in the molten stream such that the combined stream, when quenched into a filament, exhibits thick and thin regions along its length. When a number of these filaments are combined into a yarn and relaxed, a highly useful degree of crimp is obtained, and fabrics made from the yarn have an unusual soft, luxuriant hand. However, reproducibly manufacturing the spinnerets with converging capillaries is quite difficult.

According to the invention, these and other difficulties of the prior art are reduced or avoided by the process disclosed below.

DEFINITIONS AND TEST METHODS

"Polyester" as used herein means those polymers of fiber-forming molecular weight composed of at least 85% by weight of an ester or esters of one or more dihydric alcohols and terephthalic acid.

The term "fully drawn denier" as used herein means the denier the filament would have if drawn at 50 meters per minute in contact with a 50 cm hot shoe heated to a temperature of 90°C, with the draw ratio selected to give an elongation-to-break of 35%.

The shrinkage profile (and 5 cm shrinkages) are determined by separating from the yarn bundle a single filament 2.5 meters long, care being taken not to stretch the filament. The filament is then cut into consecutive serially numbered 5 cm samples or segments, which are then placed while unrestrained in boiling water for 30 seconds. The length of each segment is then measured, and its shrinkage as a percentage of the original 5 cm length is calculated. For example, if a segment has a length of 4.2 cm after the treatment with boiling water, its shrinkage would be 16%. The percentage shrinkages, when plotted in serial number order, provides a profile of shrinkage variation along the filament.

In contrast to the above 5 cm shrinkage test of individual filaments, yarn properties are determined in the following manner. The yarn is conditioned for at least one hour in an atmosphere of 22°C and 65% relative humidity. If the yarn is wound on a package, at least 100 meters are stripped off and discarded. The yarn is skeined under a tension of 0.035 grams per denier on a Suter denier reel or equivalent device having a perimeter of 1.125 meters per revolution to a total skein denier of approximately (but not to exceed) 8000, and the ends are tied. For example, for a 170 denier yarn, 23 revolutions would give a skein denier of 8160. In this instance, 23 revolutions would be used. The skein is removed from the denier reel and suspended from a 1.27 cm diameter round bar. A 1000 gram weight is

gently lowered until the weight is suspended from the bottom of the skein by a bent no.1 paper clip or equivalent piece of wire weighing less than 1 gram. After 30 seconds, the skein length is measured to the nearest 0.1 cm, the measured length being recorded as L_o. The 1000 gm weight is then replaced with a 20 gm weight, and the rod with the suspended skein and 20 gm weight are placed in a 120°C oven for 5 minutes. The rod with the suspended skein and 20 gm weight is removed from the oven and conditioned for 1 minute at 22°C and 65% relative humidity, after which the skein length L_1 is determined to the nearest 0.1 cm. The 20 gm weight is then carefully replaced by the 1000 gm weight. Thirty seconds after the 1000 gm weight has been applied, the skein length L_2 is determined to the nearest 0.1 cm. The percentage crimp is then calculated as

$$\frac{L_2 - L_1}{L_2} \times 100,$$

while the percentage yarn shrinkage is calculated as

$$\frac{L_o - L_2}{L_0} \times 100$$

Occasionally the filaments in a skein will be so highly entangled that, when the 20 gm weight is replaced by the 1000 gm weight, the length L_2 is about the same as L_1, even though the skein obviously has not had its crimp pulled out. In such a case, the 1000 gm weight may be gently jarred until the weight falls and removes the crimp.

To characterize a yarn, 100 samples are tested by the procedures in this paragraph, the highest 10 and lowest 10 values being discarded and the remainder averaged to arrive at crimp and shrinkage values for the yarn.

DESCRIPTION OF THE INVENTION

According to a first major aspect of the invention, there is provided a process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament

to filament, at least one of the plurality of filaments being generated by the steps comprising extruding from substantially parallel spinneret capillaries at least first and second molten streams of polyester polymer of fiber-forming molecular weight, the first stream having a greater velocity than the second stream and being spaced laterally from the second stream a small distance selected such that the first and second streams unite into a combined stream having thick and thin regions; attenuating and quenching the combined stream into the one filament; and withdrawing the one filament from the combined stream at a given spinning speed, the spinning speed and the velocities and lateral spacing upon extrusion of the first and second streams being selected such that the shrinkage peaks and valleys along the one filament are substantially regularly spaced. According to another aspect of the invention, the one filament has an average fully drawn denier less than 6. According to another aspect of the invention, the first stream is larger than the second stream. According to another aspect of the invention, the first stream has a velocity between 2 and 7 times as fast as the second stream.

According to a second major aspect of the invention, there is provided a process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to filament, at least one of the plurality of filaments being generated by the steps comprising extruding from substantially parallel spinneret capillaries at least first and second molten streams of polyester polymer of fiber-forming molecular weight, the first stream having a greater velocity than the second stream and being spaced laterally from the second stream a small distance selected such that the first and second streams unite below the spinneret into a combined stream having thick and thin regions; attenuating and quenching the combined stream into the one filament; and withdrawing the one filament from the combined stream at a given spinning speed, the spinning speed and the velocities and lateral spacing upon extrusion of the first and second streams

being selected such that the one filament has per 5 meters along its length an average of at least two regions possessing shrinkage peaks having at least two consecutive 5 cm shrinkages above 40%, and regions possessing shrinkage valleys between the peaks, the valleys having at least two consecutive 5 cm shrinkages below 20%. According to another aspect of the invention, the one filament has an average fully drawn denier less than 6. According to another aspect of the invention, the first stream is larger than the second stream. According to another aspect of the invention, the first stream has a velocity between 2 and 7 times as fast as the second stream.

According to a third major aspect of the invention, there is provided a process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to filament, at least one of the plurality of filaments being generated by the steps comprising extruding from substantially parallel spinneret capillaries at least first and second molten sub-streams of polyester polymer of fiber-forming molecular weight, the first sub-stream having a greater velocity than the second sub-stream and being spaced laterally from the second sub-stream a small distance selected such that the first and second sub-streams unite below the spinneret into a combined stream having thick and thin regions; attenuating and quenching the combined stream into the one filament; and withdrawing the one filament from the combined stream at a given spinning speed, the spinning speed and the velocities and lateral spacing upon extrusion of the first and second sub-streams being selected such that the yarn has a crimp-to-shrinkage ratio above 0.25. According to another aspect of the invention, the one filament has an average fully drawn denier less than 6. According to another aspect of the invention, the first stream is larger than the second stream. According to another aspect of the invention, the first stream has a velocity between 2 and 7 times as fast as the second stream.

According to a fourth major aspect of the invention,

there is provided a process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to filament, at least one of the plurality of filaments being generated by the steps comprising extruding from substantially parallel spinneret capillaries at least first and second molten streams of polyester polymer of fiber-forming molecular weight, the first stream having a greater velocity than the second stream and being spaced laterally from the second stream a small distance selected such that the first and second streams unite below the spinneret into a combined stream having thick and thin regions; attenuating and quenching the combined stream into the one filament; and withdrawing the one filament from the combined stream at a given spinning speed, the spinning speed and the velocities and lateral spacing upon extrusion of the first and second streams being selected such that the yarn has a crimp of at least 2.5%. According to another aspect of the invention, the one filament has an average fully drawn denier less than 6. According to another aspect of the invention, the first stream is larger than the second stream. According to another aspect of the invention, the first stream has a velocity between 2 and 7 times as fast as the second stream. According to another aspect of the invention, the yarn has a crimp of at least 5%.

Other aspects of the invention will in part appear hereinafter and will in part be obvious from the following detailed description taken together with the accompanying drawings, wherein:

FIGURE 1 is a plan view of a portion of the lower or extrusion face of an exemplary type of spinneret usable in the process of the invention;

FIGURE 2 is a schematic side view of the molten streams just below the face of the FIGURE 1 spinneret, and

FIGURES 3-6 are graphs of shrinkage profiles of various filaments, as will be set forth below.

As shown in FIGURES 1 and 2, polyester polymer is melt spun through substantially parallel capillaries 20 and 22 in spinneret 24 to provide at least two molten sub-streams, one of which has a higher velocity than the other. The capillaries are spaced laterally a small distance selected such that the sub-streams unite below the spinneret into a combined stream having thick and thin regions. For example, in the preferred embodiment, capillary 20 may have a diameter of 0.305 mm while satellite capillaries 22 have diameters of 0.203 mm the centers of capillaries 22 being 0.356 mm from the center of and located on opposite sides of capillary 20, all capillaries being 0.305 mm in length. Capillary 20 and its associated satellite capillaries 22 cooperate as a combined orifice for spinning a single filament, schematically shown in FIGURE 2. Ordinarily, a plurality of combined orifices will be provided in a single spinneret so that the resulting multifilament yarn comprises more than one of the filaments according to the invention.

It is essential that one of the sub-streams has a higher velocity than at least one other of the sub-streams which unite to form a combined stream. FIGURE 2 illustrates qualitatively the resulting action of the molten sub-streams immediately below the spinneret specifically described above. Since all the capillaries in this instance are the same length, the sub-stream issuing from capillary 20 has a higher velocity upon extrusion than the sub-streams issuing from capillaries 22. The center substream accordingly alternately strikes and bonds to one of the outer sub-streams, then buckles and strikes and bonds to the other of the outer sub-streams. The combined stream thus formed is attenuated and the various sub-streams unite side-by-side to form a stream having thick and thin regions along its length. This stream is quenched as it is accelerated to the spinning speed, ie, the speed at which the filament travels immediately after solidification. The resulting filament has properties uniquely determined by spinning speed.

EXAMPLE 1

This is an example within the teachings of Example 3 of Japanese patent publication 22339/1967. A spinneret having 34 combined orifices is provided, each combined orifice being constituted by a central capillary having a diameter of 0.300 mm and three satellite capillaries having diameters of 0.200 mm. The satellite capillaries are equally spaced apart around the central capillary with their centers 0.400 mm from the center of the central capillary, and all capillaries have a length of 0.305 mm. Polyester polymer of normal molecular weight for apparel yarns is spun through the spinneret at a melt temperature of 300°C, at a rate of 73.5 grams per minute. The combined streams are conventionally quenched by transversely directed air into filaments at a spinning speed of 400 meters per minute and wound on a package.

The spun yarn is then conventionally drawn over a hot shoe heated to 90°C at a draw ratio of 4.0 to yield a drawn yarn having a denier of 416, 33% elongation-to-break, tenacity of 2.7 grams per denier, shrinkage of 13.4% and crimp of 1.2%. The denier per filament is about 12, and fabric made from the yarn has poor cover and a harsh hand. Generally speaking, crimp is a desirable property while shrinkage is undesirable. The crimp-to-shrinkage ratio is thus a measure of the general desirability of the yarn. This low level of crimp, and the low value of the crimp-to- shrinkage ratio, makes the yarn far less valuable than yarns made according to the present invention.

The shrinkage profile along a filament from the drawn yarn has the random character generally depicted in FIGURE 3. While successive sample numbers 42 and 43 in FIGURE 3 have shrinkages above 40%, this is not common in yarns spun at the low speeds of this example.

EXAMPLE 2

The spun yarn in Example 1 is similarly drawn at a draw ratio of 3.2 to produce a drawn yarn having a denier of 515, elongation of 42%, tenacity of 1.6 grams per denier,

shrinkage of 16.1%, and a crimp of 3.0%. The denier per filament is about 15, and fabric made from the yarn also has poor cover and a harsh hand, as in Example 1. While the crimp level is marginally useful, the undesirably low crimp-to-shrinkage ratio makes the yarn undesirable for many end uses. The shrinkage profile is again similar to FIGURE 3.

EXAMPLE 3

Example 1 is repeated except that the spinneret is replaced with the preferred embodiment of the FIGURE 1 spinneret there being 34 combined orifices. The spun yarn is hot-drawn at a draw ratio of 2.80 to yield a drawn denier of 565, an elongation of 102%, tenacity of 1.85, shrinkage of 22%, and a crimp of 1.8%. FIGURE 3 is an actual shrinkage profile of a filament produced according to this example. Fabric made from this yarn has very poor cover and a quite harsh hand.

When using any of the spinnerets referred to above, random occurrence of shrinkage peaks of random amplitude and valleys along the length of the filaments is inherent when spinning at low speeds. As the spinning speed is increased above some level, a degree of regularity is achieved which is advantageous for various end uses. The spinning speed at which the almost wholly random character of the shrinkage profile changes to discernible regularity depends on spinneret design, polymer throughput rate, spun denier-per-filament, quenching conditions, and other similar parameters, and can readily be determined by simply increasing the spinning speed until the shrinkage profile displays substantial regularity. With the above spinnerets, ordinarily regularity becomes apparent in the vicinity of 1500-2500 meters per minute. With this particular spinneret, regularity begins to be apparent at about 2000 ypm (about 1800 mpm) as spinning speed is increased. The degree of crimp and the crimp-to-shrinkage ratio also ordinarily increase substantially at spinning speeds far above the 400 meters per minute suggested in Japanese patent publication 22339/1967, as illustrated in the following examples.

EXAMPLE 4

Polyester polymer is melt spun at 300°C from the above preferred embodiment of the FIGURE 1 spinneret at a spinning speed of 3800 ypm (about 3420 meters per minute), the polymer rate being selected such that the resulting yarn has an average denier per filament (dpf) of 4.1. The shrinkage profile for a filament from this yarn is illustrated in FIGURE 4. In contrast to the random pattern characteristic of slow speed spinning, the FIGURE 4 filament has a pattern of quite regularly recurring broad shrinkage peaks alternating with broad shrinkage valleys. The yarn has a shrinkage of 32.9% and a crimp of 15.5% for a crimp-to-shrinkage ratio of 0.47. The yarn is particularly suited for being draw-textured using a friction aggregate, downstream of the primary heater, for applying false twist, the draw ratio and aggregate speed being selected such that the filaments are broken in or after the aggregate to yield a spun-like yarn with broken filaments protruding from the yarn. The regularity of recurrence of the high and low shrinkage regions permits better control of the number of broken filaments per meter of yarn by selection of the draw-texturing process conditions. The breadth of the shrinkage peaks and valleys also contribute in this regard. By breadth is meant that at least two consecutive 5 cm shrinkages along an individual filament are above 40%, in the case of a shrinkage peak, or are below 20% in the case of a shrinkage valley.

EXAMPLE 5

Example 4 is repeated except that the spinning speed is increased to 5000 yards per minute (about 4500 meters per minute), and the polymer throughput is adjusted to provide an average of 3.2 denier per filament in the resulting yarn. The yarn has a crimp of 4.4% and a shrinkage of 9.7%, to give a crimp-to-shrinkage ratio of 0.45. Figures 5 and 6 are shrinkage profiles of two filaments from the same yarn, and illustrate the substantial regularity of occurrence of the shrinkage peaks and valleys. These figures also illustrate that the shrinkage

peaks and valleys are out of phase from filament to filament, and indeed have somewhat different repetition rates. Since the yarn was spun at high speed, it is sufficiently highly oriented to be capable of direct use in fabrics, giving an unusually soft hand and excellent cover, as compared to a conventionally textured yarn of equal number of filaments and equal denier per filament.

CLAIMS:

1. A process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to filament, at least one of said plurality of filaments being generated by the steps comprising:

a. extruding from substantially parallel spinneret capillaries at least first and second molten streams of polyester polymer of fiber-forming molecular weight, said first stream having a greater velocity than said second stream and being spaced laterally from said second stream a small distance selected such that said first and second streams unite below said spinneret into a combined stream having thick and thin regions;

b. attenuating and quenching said combined stream into said one filament; and

c. withdrawing said one filament from said combined stream at a given spinning speed, said spinning speed and the velocities and lateral spacing upon extrusion of said first and second streams being selected such that said shrinkage peaks and valleys along said one filament are substantially regularly spaced.

2. The process defined in claim 1, wherein said one filament has an average fully drawn denier less than 6.

3. The process defined in claim 1, wherein said first stream is larger than said second stream.

4. The process defined in claim 1, wherein said first stream has a velocity between 2 and 7 times as fast as said second stream.

5. A process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to

filament, at least one of said plurality of filaments being generated by the steps comprising:

a. extruding from substantially parallel spinneret capillaries at least first and second molten streams of polyester polymer of fiber-forming molecular weight, said first stream having a greater velocity than said second stream and being spaced laterally from said second stream a small distance selected such that said first and second streams unite below said spinneret into a combined stream having thick and thin regions;

b. attenuating and quenching said combined stream into said one filament; and

c. withdrawing said one filament from said combined stream at a given spinning speed, said spinning speed and the velocities and lateral spacing upon extrusion of said first and second streams being selected such that said one filament has per 5 meters along its length an average of at least two regions possessing shrinkage peaks having at least two consecutive 5 cm shrinkages above 40%, and regions possessing shrinkage valleys between said peaks, said valleys having at least two consecutive 5 cm shrinkages below 20%.

6. The process defined in claim 5, wherein said one filament has an average fully drawn denier less than 6.

7. The process defined in claim 5, wherein said first stream is larger than said second stream.

8. The process defined in claim 5, wherein said first stream has a velocity between 2 and 7 times as fast as said second stream.

9. A process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to filament, at least one of said plurality of filaments being generated by the steps comprising:

a. extruding from substantially parallel spinneret capillaries at least first and second molten sub-streams of polyester polymer of fiber-forming molecular weight, said first sub-stream having a greater velocity than said second sub-stream and being spaced laterally from said second sub-stream a small distance selected such that said first and second sub-streams unite below said spinneret into a combined stream having thick and thin regions;

b. attenuating and quenching said combined stream into said one filament; and

c. withdrawing said one filament from said combined stream at a given spinning speed, said spinning speed and the velocities and lateral spacing upon extrusion of said first and second sub-streams being selected such that said yarn has a crimp-to-shrinkage ratio above 0.25.

10. The process defined in claim 9, wherein said one filament has an average fully drawn denier less than 6.

11. The process defined in claim 9, wherein said first stream is larger than said second stream.

12. The process defined in claim 9, wherein said first stream has a velocity between 2 and 7 times as fast as said second stream.

13. A process for forming a yarn, comprising generating a bundle comprising a plurality of polyester filaments having shrinkage peaks and valleys out of phase from filament to filament, at least one of said plurality of filaments being generated by the steps comprising:

a. extruding from substantially parallel spinneret capillaries at least first and second molten streams of polyester polymer of fiber-forming molecular weight, said first stream having a greater velocity than said second stream and being spaced laterally from said second stream a small distance selected subh that said first and second streams unite below said spinneret into a combined stream having thick and thin regions;

b. attenuating and quenching said combined stream into said one filament; and

c. withdrawing said one filament from said combined stream at a given spinning speed, said spinning speed and the velocities and lateral spacing upon extrusion of said first and second streams being selected such that said yarn has a crimp of at least 2.5%.

14. The process defined in claim 13, wherein said one filament has an average fully drawn denier less than 6.

15. The process defined in claim 13, wherein said first stream is larger than said second stream.

16. The process defined in claim 13, wherein said first stream has a velocity between 2 and 7 times as fast as said second stream.

17. The process defined in claim 13, wherein said yarn has a crimp of at least 5%.

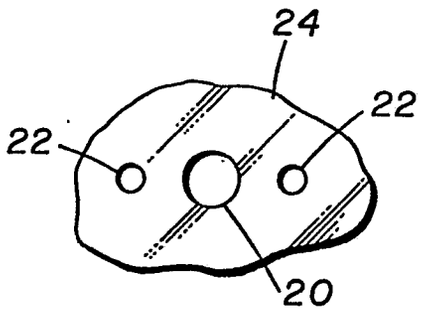

FIG.1.

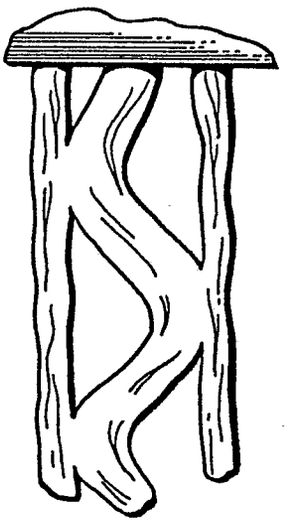

FIG.2.

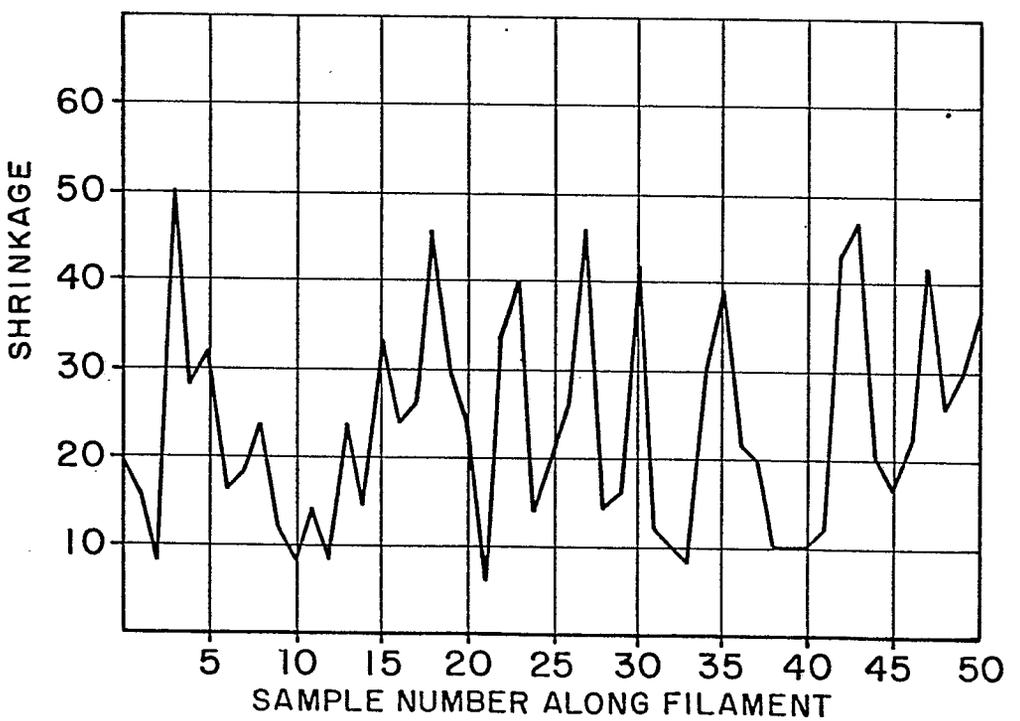

FIG. 3.

(PRIOR ART)

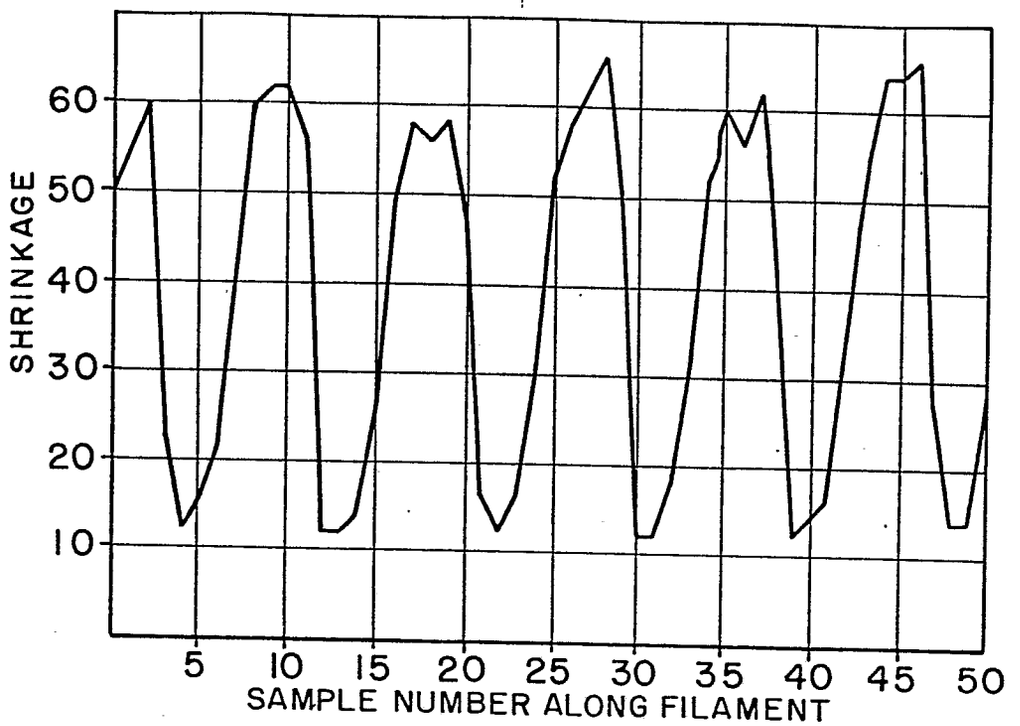
SHRINKAGE
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FIG. 4.

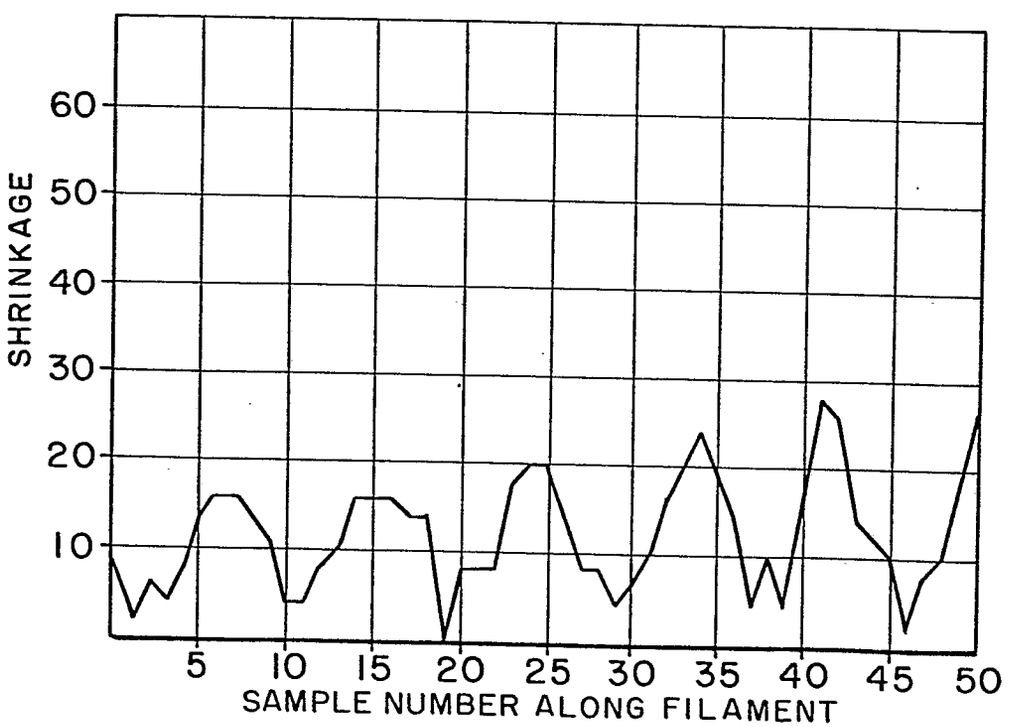
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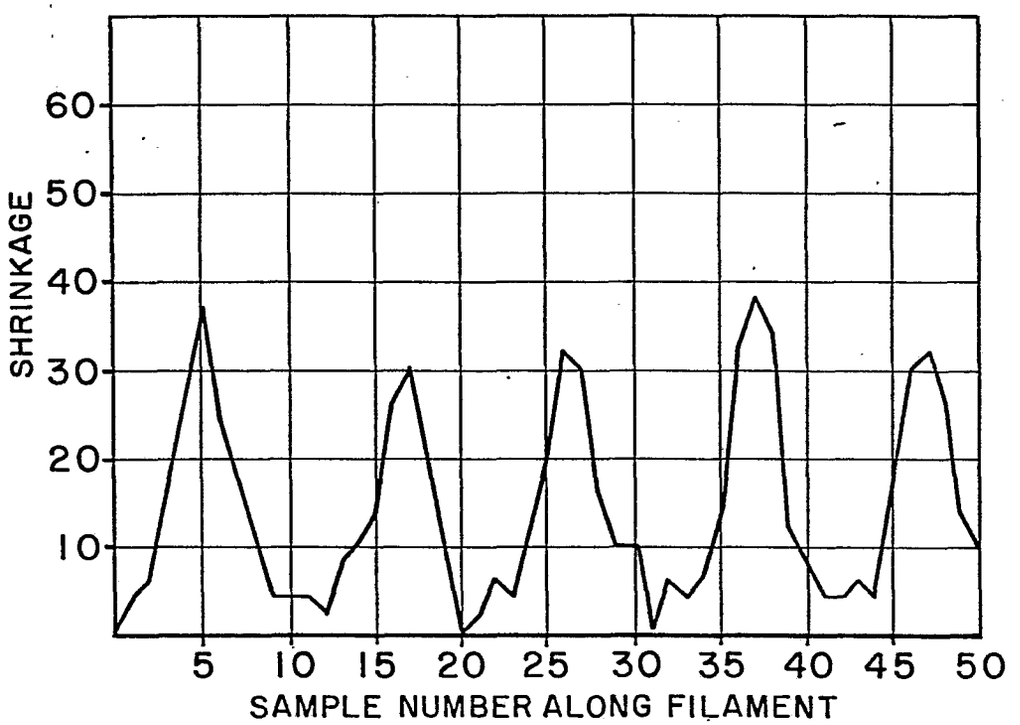
FIG. 5.


SHRINKAGE
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SAMPLE NUMBER ALONG FILAMENT

FIG. 6.

European Patent Office

EUROPEAN SEARCH REPORT

0041820
Application number
EP 81 30 2448

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
D	GB - A - 2 003 423 (MONSANTO) * the whole document * & JP - A - 54 042 415	1-17	D 01 D 5/22 5/32
	EP - A - 0 009 883 (MONSANTO) * the whole document *	1-17	
A	GB - A - 2 017 575 (MONSANTO)		

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

D 01 D 5/32
5/22
5/20

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14-09-1981	VAN GOETHEM

EPO Form 1503.1 06.78